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PATENT

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Applicant: Hiroshi Haji et al. : Art Unit
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FOR: METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents
Washington, D.C. 20231
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2. That I am knowledgeable in the English language and in the language of JP2000-034707, and I believe the attached English translation to be a true and complete translation of JP2000-034707.

3. The document for which the attached English translation is being submitted is a patent application on an invention entitled METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so

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Date: 6 August, 2003

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[TITLE OF THE INVENTION] Semiconductor Device Manufacturing Method and Semiconductor Device

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[Title of the Invention] Semiconductor Device Manufacturing Method and Semiconductor Device

[What is claimed is:]

[Claim 1] A method of manufacturing a semiconductor device having a resin layer on an electrode forming surface with electrodes formed thereon for external connection of semiconductor elements, and metallic bumps penetrating the resin layer to become conductive with said electrodes, comprising a step of partial separation for cutting and separating only either semiconductor wafer with a plurality of semiconductor elements formed thereon or resin layer formed on the surface of the semiconductor wafer; a step of placing conductive balls on the top surface of the resin layer after the step of partial separation in order to form metallic bumps conductive with said electrodes; and a step of complete separation for separating the semiconductor wafer into individual semiconductor devices after forming metallic bumps.

[Claim 2] A semiconductor device formed with a resin layer on an electrode forming surface with electrodes formed thereon for external connection of semiconductor elements and with metallic bumps penetrating the resin layer to become conductive with said electrode, which is manufactured by a method of manufacturing a semiconductor device, comprising a step of partial separation for cutting and separating only either semiconductor wafer with

a plurality of semiconductor elements formed thereon or resin layer formed on the surface of the semiconductor wafer; a step of placing conductive balls on the top surface of the resin layer after the step of partial separation in order to form metallic bumps conductive with said electrodes; and a step of complete separation for separating semiconductor wafer into individual semiconductor devices after forming metallic bumps.

[Detailed Description of the invention]

[0001]

[Field of the Invention]

The present invention relates to a semiconductor device manufacturing method in which metallic bumps are formed on electrodes for external connection of semiconductor elements, and a semiconductor device.

[0002]

[Prior Art]

A semiconductor device mounted on a substrate of electronic equipment or the like has been conventionally manufactured through the steps of: forming a circuit pattern in a state of wafer by connecting lead frame pins or metallic bumps to electrodes for external connection of semiconductor elements after being divided into individual pieces and packaging for making a semiconductor device by sealing the entire semiconductor elements including the connections by means of resin mold. Recently, a method of manufacturing a

semiconductor device is employed, in which the step of packaging is performed in a state of wafer. In this method, a resin layer is first formed on the surface of semiconductor wafer, and after forming a two-layer structure of semiconductor wafer and resin layer, the step of forming electrodes for external connection such as metallic bumps is executed. For forming metallic bumps, a method of placing conductive balls on resin layer is generally employed.

[0003]

[Problems to be Solved by the Invention]

However, a two-layer structure with resin layer formed on semiconductor wafer is liable to warp due to thermal deformation because of difference in thermal expansion coefficient between silicon, main material for semiconductor wafer, and resin material. Accordingly, in the step of placing conductive balls on the resin layer, gaps are partially created due to such warping between the surface of resin layer and the underside of conductive ball in a state of being held by transfer head. In the condition, if conductive balls are placed, there arises a problem that the conductive balls cannot be placed in normal conditions because of deflection or removal caused due to fall at the gaps when the conductive balls are released from a state of being vacuum-attracted and transferred onto the top surface of the resin layer.

[0004]

The present invention is intended to provide a semiconductor device manufacturing method capable of preventing the deformation of conductor wafer and placing conductive balls in normal conditions, and a semiconductor device.

[0005]

[Means to Solve the Problems]

The semiconductor manufacturing method of claim 1 is a method of manufacturing a semiconductor device having a resin layer on an electrode forming surface with electrodes formed thereon for external connection of semiconductor elements, and metallic bumps penetrating the resin layer to become conductive with the electrodes, which includes a step of partial separation for cutting and separating only either semiconductor wafer with a plurality of semiconductor elements formed thereon or resin layer formed on the surface of the semiconductor wafer; a step of placing conductive balls on the top surface of the resin layer after the step of partial separation in order to form metallic bumps conductive with the electrodes; and a step of complete separation for separating semiconductor wafer into individual semiconductor devices after forming metallic bumps.

[0006]

The semiconductor device of claim 2 is a semiconductor device having a resin layer on an electrode forming surface with electrodes formed thereon for external connection of

semiconductor elements, and metallic bumps penetrating the resin layer to become conductive with the electrode, which is manufactured a method of manufacturing a semiconductor device, which includes a step of partial separation for cutting and separating only either semiconductor wafer with a plurality of semiconductor elements formed thereon or resin layer formed on the surface of the semiconductor wafer; a step of placing conductive balls on the top surface of the resin layer after the step of partial separation in order to form metallic bumps conductive with the electrodes; and a step of complete separation for separating semiconductor wafer into individual semiconductor devices after forming metallic bumps.

[0007]

In the present invention, only either semiconductor wafer with a plurality of semiconductor elements formed thereon or resin layer formed on the surface of the semiconductor wafer is cut and separated, and conductive balls are placed on the top surface of the resin layer after the step of partial separation in order to form metallic bumps conductive with the electrodes. Accordingly, the semiconductor wafer is free from warping due to thermal deformation when conductive balls are placed for forming metallic bumps, and it is possible to place conductive balls in normal conditions.

[0008]

[Description of the Preferred Embodiment]

(Preferred Embodiment 1)

Fig. 1 and Fig. 2 are explanatory diagrams of semiconductor device manufacturing process in the preferred embodiment 1 of the present invention. Fig. 1 (a), (b), (c), (d) and Fig. 2 (a), (b), (c), (d) show the semiconductor device manufacturing method in the order of steps.

[0009]

In Fig. 1 (a), reference numeral 1 is a semiconductor wafer with a plurality of semiconductor elements formed thereon. On the top surface of the semiconductor wafer 1 is formed electrodes 2 for external connection. As shown in Fig. 1 (b), resin layer 3 is formed on the electrode forming surface of semiconductor wafer 1. As a method of forming resin layer, in the present preferred embodiment, resin material such as epoxy resin and polyimide resin formed into a sheet of resin film of about 200 μm in thickness is coated on the top surface of semiconductor wafer 1. As a method of forming the resin layer 3, it is also preferable to employ a method of uniformly coating liquid resin instead of resin film on the electrode forming surface.

[0010]

The resin layer 3 not only protects the surface of semiconductor wafer 1 but also functions as sealing resin as it is even after semiconductor element 1' is cut out of the semiconductor wafer 1. Accordingly, a material having sealing function to protect the semiconductor element 1' is employed

as resin material for the resin layer 3. That is, the material is required to ensure satisfactory performance as a sealing material such as sufficient strength and electrical insulation with respect to moisture resistance, anti-migration property, and external forces. Such resin is preferable to be the one that has been already used for the manufacture of semiconductor devices. Also, it is preferable to mix a filler such as SiO_2 into the resin in order to enhance the reliability after mounting semiconductor devices on a substrate.

[0011]

Next, the semiconductor wafer 1 with the resin layer 3 formed thereon is delivered to a back thinning step. As shown in Fig. 1 (c), the back of semiconductor wafer 1 or the opposite side of the surface with the resin layer 3 formed is ground (see the semiconductor wafer 1 shown by broken line). While the semiconductor wafer 1 is thinned by grinding, it will be also subjected to machining stresses, but there is no fear of breakdown because it is reinforced by the resin layer 3.

[0012]

Subsequently, through-hole forming is executed on the semiconductor wafer 1 being in the above condition. The through-hole forming is executed by laser beam machining for forming through-hole 3a that penetrates the resin layer 3 in accordance with the position of electrode 2. By applying a laser beam to the specified position of the resin layer 3, the

through-hole 3a reaching the surface of electrode 2 is formed in the resin layer 3 as shown in Fig. 2 (a). Also, as through-hole forming is executed, in this step, only the resin layer 3 is cut and separated along the division line of each individual piece by means of the laser beam. That is, this step is a step of partial separation for cutting and separating only the resin layer 3.

[0013]

Next, a step of forming metallic bumps conductive with the electrode 2 at the position of through-hole 3a will be described. As shown in Fig. 2 (a), cream solder 5 is filled into the through-hole 3a by using a spatula such as a squeegee. Subsequently, solder balls 6 as conductive balls are placed on the cream solder 5 filled into the through-hole 3a of resin layer 3 by using attracting head 8 as shown in Fig. 2 (b). The solder balls 6 are formed by same solder as the cream solder 5.

[0014]

Since the resin layer 3 is cut and separated at positions corresponding to individual pieces before the solder ball placing step, the two-layer structure with the resin layer 3 continuously bonded to the semiconductor wafer 1 is free from warping due to thermal deformation. Consequently, when the solder balls 6 are placed by using the attracting head 8, the top surface of the resin layer 3 is kept at a uniform height, allowing no gaps to be created between the solder balls 6 held

by the attracting head 8 and the top surface of the resin layer 3. Accordingly, there is no fear of problems such as deflection or removal caused due to falling of solder balls 6 into the gaps in case of placing the solder balls 6 in a warped state of the structure.

[0015]

After that, the semiconductor wafer 1 is delivered to a reflow process where it is heated. Then, solder particles in the solder ball 6 and cream solder 5 are melted and soldered to the top of electrode 2. In this way, as shown in Fig. 2 (c), metallic bump 7 is formed, which penetrates the resin layer 3 to become conductive with the electrode 2.

[0016]

The semiconductor wafer 1 with metallic bumps 7 formed as described above is set in a cutting means. By cutting the semiconductor wafer 1 along the cutting positions of resin layer 3, the semiconductor wafer 1 is separated into individual pieces of semiconductor element 1' and then completely separated. In this way, semiconductor device 9 provided with resin layer 3 formed on the electrode forming surface of the semiconductor element 1' and with metallic bump 7 penetrating the resin layer 3 to become conductive with the electrode 2 is completed as shown in Fig. 2 (d).

[0017]

(Preferred Embodiment 2)

Fig. 3 and Fig. 4 are explanatory diagrams of semiconductor device manufacturing process in the preferred embodiment 2 of the present invention. Fig. 3 (a), (b), (c), (d) and Fig. 4 (a), (b), (c), (d) show the semiconductor device manufacturing method in the order of steps. The preferred embodiment 2 is different from the preferred embodiment 1 in the step of partial separation of the two-layer structure of semiconductor wafer and resin layer, wherein only the semiconductor wafer is cut and separated.

[0018]

In Fig. 3 (a), reference numeral 11 is semiconductor wafer with a plurality of semiconductor elements formed thereon the same as the semiconductor wafer 1 in the preferred embodiment 1. On the top surface of the semiconductor wafer 11 is formed electrode 12 for external connection. The steps of forming resin layer and thinning semiconductor wafer 11 to be executed thereafter are same as in the preferred embodiment 1 shown in Fig. 1 (b), (c).

[0019]

Next, the steps of forming through-holes and cutting semiconductor wafer 11 are executed on the semiconductor wafer 11 being in the above condition. The step of forming through-holes is executed by laser beam machining the same as in the preferred embodiment 1, and thereby, through-holes 13a reaching the surface of electrodes 12 are formed in the resin

layer 13 as shown in Fig. 3 (d). Also, with the through-holes formed, in this step, only the semiconductor wafer 11 is cut into individual pieces along the division line, cutting and separating it into individual pieces of semiconductor elements 11'. That is, this step is a step of partial separation for cutting and separating only the semiconductor wafer 11.

[0020]

After that, metallic bumps conductive with electrodes 12 are formed at the positions of through-holes 13a. Here, as shown in Fig. 4 (a) the same as in the preferred embodiment 1, cream solder 5 is filled into the through-holes 13a, and subsequently, solder balls 6 are placed on the through-holes 13a of resin layer 13 as shown in Fig. 4 (b).

[0021]

Since the semiconductor wafer 11 is cut and separated at positions corresponding to individual pieces before the step of placing solder balls, the two-layer structure with the semiconductor wafer 11 continuously bonded to the resin layer 13 is free from warping due to thermal deformation, and therefore, same as in the preferred embodiment 1, there is no fear of problems such as deflection or removal of solder balls 6 when placing the solder balls 6.

[0022]

After that, the semiconductor wafer 11 with the semiconductor elements 11' bonded by the resin layer 13 is

delivered to the reflow process where it is heated the same as in the preferred embodiment 1. In this way, as shown in Fig. 4 (c), metallic bumps 7 conductive with the electrodes 12 are formed on the top surface of the resin layer 13.

[0023]

As described above, the semiconductor wafer 11 (semiconductor elements 11' connected structure) formed with metallic bumps 7 is set in a cutting means. Here, by cutting the resin layer 13 along the cutting position of semiconductor element 11', the semiconductor wafer 11 is separated into individual pieces and then completely separated. In this way, semiconductor device 19 provided with resin layer 13 formed on the electrode forming surface of the semiconductor element 11' and with metallic bumps 7 penetrating the resin layer 13 to become conductive with the electrodes 12 is completed as shown in Fig. 4 (d).

[0024]

(Preferred Embodiment 3)

Fig. 5 and Fig. 6 are explanatory diagrams of semiconductor device manufacturing process in the preferred embodiment 3 of the present invention. Fig. 5 (a), (b), (c), (d) and Fig. 6 (a), (b), (c), (d) show the semiconductor device manufacturing method in the order of steps. In the preferred embodiment 3, the top surface of semiconductor wafer is previously grooved, and only the semiconductor wafer is cut and separated by cutting

the back of the semiconductor wafer after forming the resin layer.

[0025]

In Fig. 5 (a), reference numeral 21 is semiconductor wafer with a plurality of semiconductor elements formed thereon the same as the semiconductor wafer 1 in the preferred embodiment 1. On the top surface of the semiconductor wafer 21 is formed electrode 22 for external connection. Resin protective sheet 25 is coated by using adhesive layer 24 on the underside of the semiconductor wafer 21. The protective sheet 25 serves to reinforce the semiconductor wafer 21 during the groove forming step described in the following.

[0026]

The semiconductor wafer 21 reinforced by the protective sheet 25 is delivered to the groove forming step. Here, as shown in Fig. 5 (b), groove 21a is formed in the top surface of semiconductor wafer 21 along the dividing positions of individual pieces. After the groove forming step, as shown in Fig. 5 (c), resin layer 23 is formed on the upper surface of semiconductor wafer 21. The resin layer is formed in the same manner as in the preferred embodiment 1.

[0027]

Next, as shown in Fig.5 (d), protective sheet 25 is removed from the underside of semiconductor wafer 21, and after that, the semiconductor wafer 21 is delivered to the thinning step.

In this step, the back of semiconductor wafer 21 is removed by grinding the same as in the preferred embodiment 1. At the time, the grinding is continued until the groove formed as in Fig. 5 (b) becomes visible from the back side. In this way, the semiconductor wafer 21 is cut and separated into individual pieces of semiconductor elements 21' because of grooves 21a. That is, in the preferred embodiment 3, only the semiconductor wafer 21 is cut and separated through the groove forming step and the thinning step, and these two steps configure the step of partial separation.

[0028]

After that, through-hole forming is executed on the semiconductor wafer 21 being in the condition. The through-hole forming is performed by laser beam machining the same as in the preferred embodiment 1. After that, metallic bumps conductive with electrodes 22 are formed in the positions of through-holes 23a. As shown in Fig. 6 (c), cream solder 5 is filled into the through-holes 23a the same as in the preferred embodiments 1, 2, and subsequently, solder balls 6 are placed on the through-holes 23a of resin layer 23 as shown in Fig. 6 (d).

[0029]

Since the semiconductor wafer 21 is cut and separated at positions corresponding to individual pieces before the solder ball placing step, the two-layer structure with the

semiconductor wafer 21 continuously bonded to the resin layer 23 is free from warping caused due to thermal deformation. Accordingly, same as in the preferred embodiments 1, 2, there arise no problems such as deflection or removal of solder balls 6 when the solder balls 6 are placed.

[0030]

After that, the semiconductor wafer 21 with the semiconductor element 21' bonded thereto by the resin layer 23 is delivered to the reflow process where it is heated, the same as in the preferred embodiments 1, 2. In this way, metallic bumps 7 conductive with electrodes 22 are formed on the resin layer 23 as shown in Fig. 6 (e).

[0031]

The semiconductor wafer 21 (semiconductor element connected structure) with metallic bumps 7 thus formed is set in a cutting means. Here, by cutting the resin layer 23 along the cutting position of semiconductor element 21', the semiconductor element 21' in a state of being continuous is separated into individual pieces and then completely separated. In this way, semiconductor device 29 provided with resin layer 23 formed on the electrode forming surface of the semiconductor element 21' and with metallic bumps 7 penetrating the resin layer 23 to become conductive with the electrodes 22 is completed as shown in Fig. 6 (f).

[0032]

As described above, in each preferred embodiment of the present invention, in the manufacture of a semiconductor device provided with a resin layer formed on semiconductor wafer and with metallic bumps penetrating the resin layer to become conductive with semiconductor elements, only either the semiconductor wafer or the resin layer is cut and separated before placing conductive balls to form metallic bumps, and thereby, the conductive balls can be efficiently placed all together on a plurality of semiconductor elements in a state of wafer, and also, it is possible to prevent warping caused due to thermal deformation at the two-layer structure of semiconductor wafer and resin layer. Accordingly, conductive balls can be placed in good conditions without gaps between the conductive balls and the resin layer in the step of placing conductive balls, and it is possible to prevent defective placing such as deflection or removal of conductive balls.

[0033]

[Advantages of the invention]

According to the present invention, only either the semiconductor wafer with a plurality of semiconductor elements formed thereon or the resin layer formed on the surface of the semiconductor wafer is cut and separated, and conductive balls are placed on the semiconductor wafer after the step of partial separation to form metallic bumps conductive with the electrodes. Accordingly, the semiconductor wafer is free from

warping caused due to thermal deformation when conductive balls are placed for forming metallic bumps, and thereby, conductive balls can be placed in normal conditions.

[Brief Description of the Drawings]

Fig 1 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 1 of the present invention.

Fig 2 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 1 of the present invention.

Fig 3 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 2 of the present invention.

Fig 4 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 2 of the present invention.

Fig 5 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 3 of the present invention.

Fig 6 is an explanatory diagram of the semiconductor device manufacturing process in the preferred embodiment 3 of the present invention.

[Description of the Reference Numerals]

1, 11, 21 Semiconductor wafer

1', 11', 21' Semiconductor element

2, 12, 22 Electrode

3, 13, 23 Resin layer

3a, 13a, 23a Through-hole

5 Cream solder

6 Solder ball

7 Metallic bump

9, 19, 29 Semiconductor device

[Name of the Document] Abstract

[Abstract]

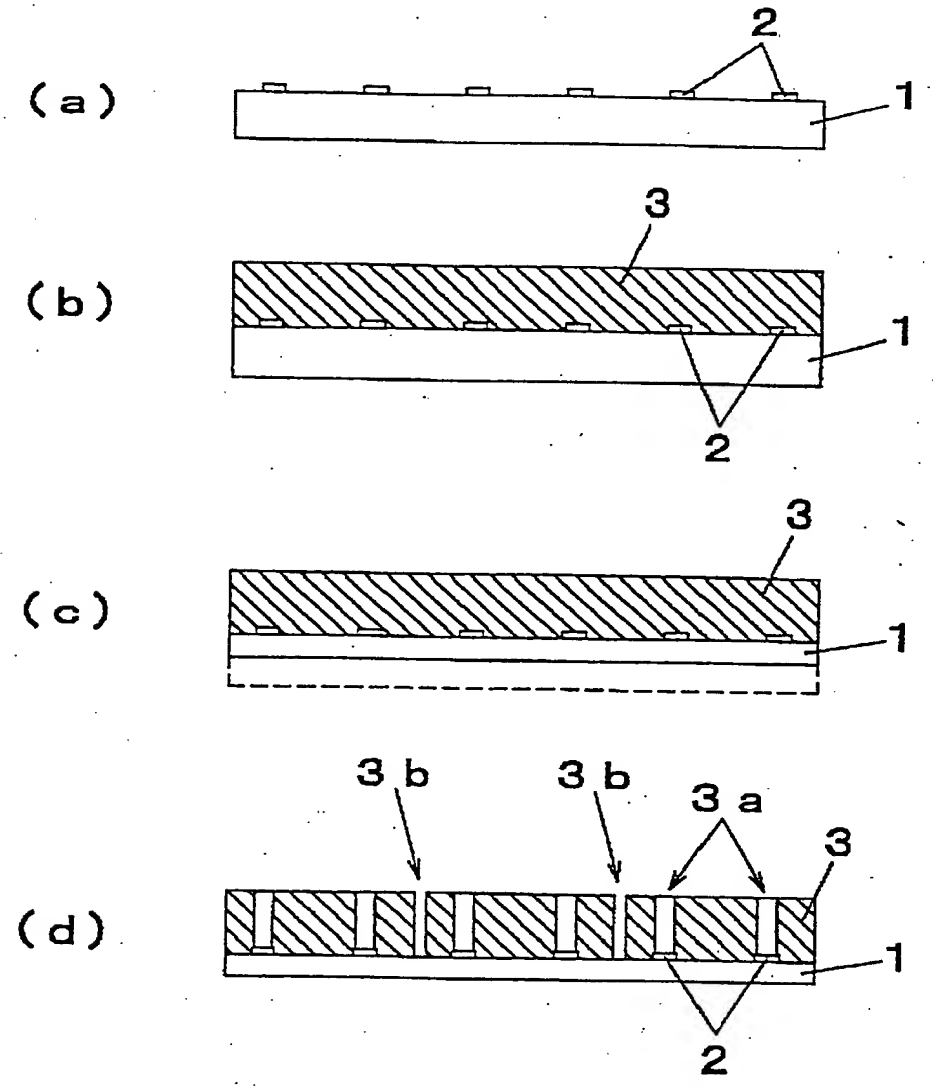
[Object] The object of the present invention is to provide a semiconductor manufacturing method capable of preventing deformation of semiconductor wafer and placing conductive balls in good conditions, and a semiconductor device.

[Means to Solve the Problems] In the method of manufacturing semiconductor device 9 provided with metallic bumps 7 which penetrate resin layer 3 formed on electrodes 2 of semiconductor element 1' to become conductive with the electrodes 2, only either semiconductor wafer 1 provided with a plurality of semiconductor elements 1' or the resin layer 3 formed on the surface of the semiconductor wafer 1 is cut and separated. Solder balls 6 are placed on the resin layer 3 by means of attracting head 8 after the step of partial separation, and metallic bumps 7 which become conductive with the electrodes 2 after reflow are formed, and thereafter, the semiconductor wafer 1 is separated into individual pieces of semiconductor devices 9. In this way, it is possible to place the solder balls 6 in normal conditions without warping caused due to thermal deformation when placing solder balls to form metallic bumps.

[Selected Drawing] Fig. 2

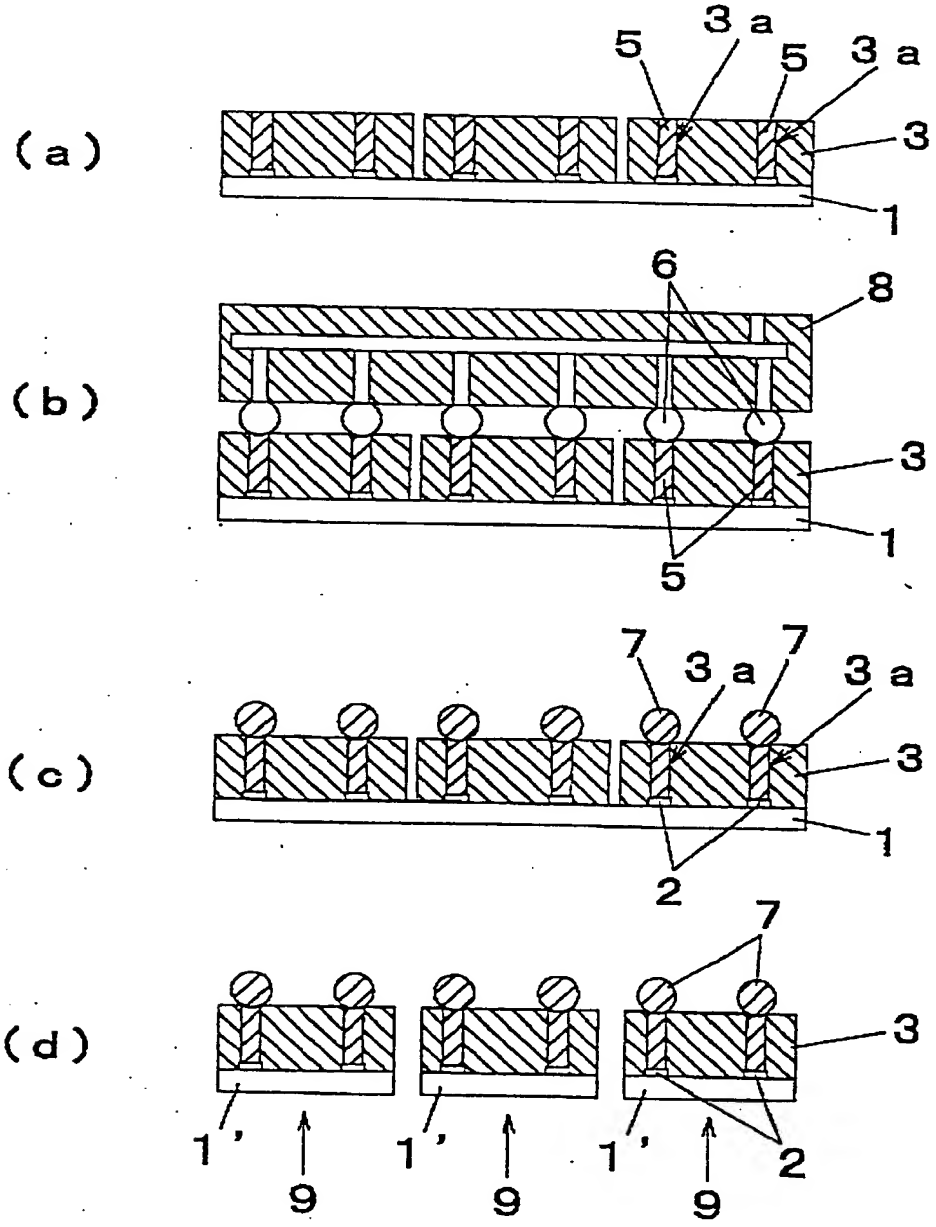
[Name of the Document] Drawings

[Fig. 1]



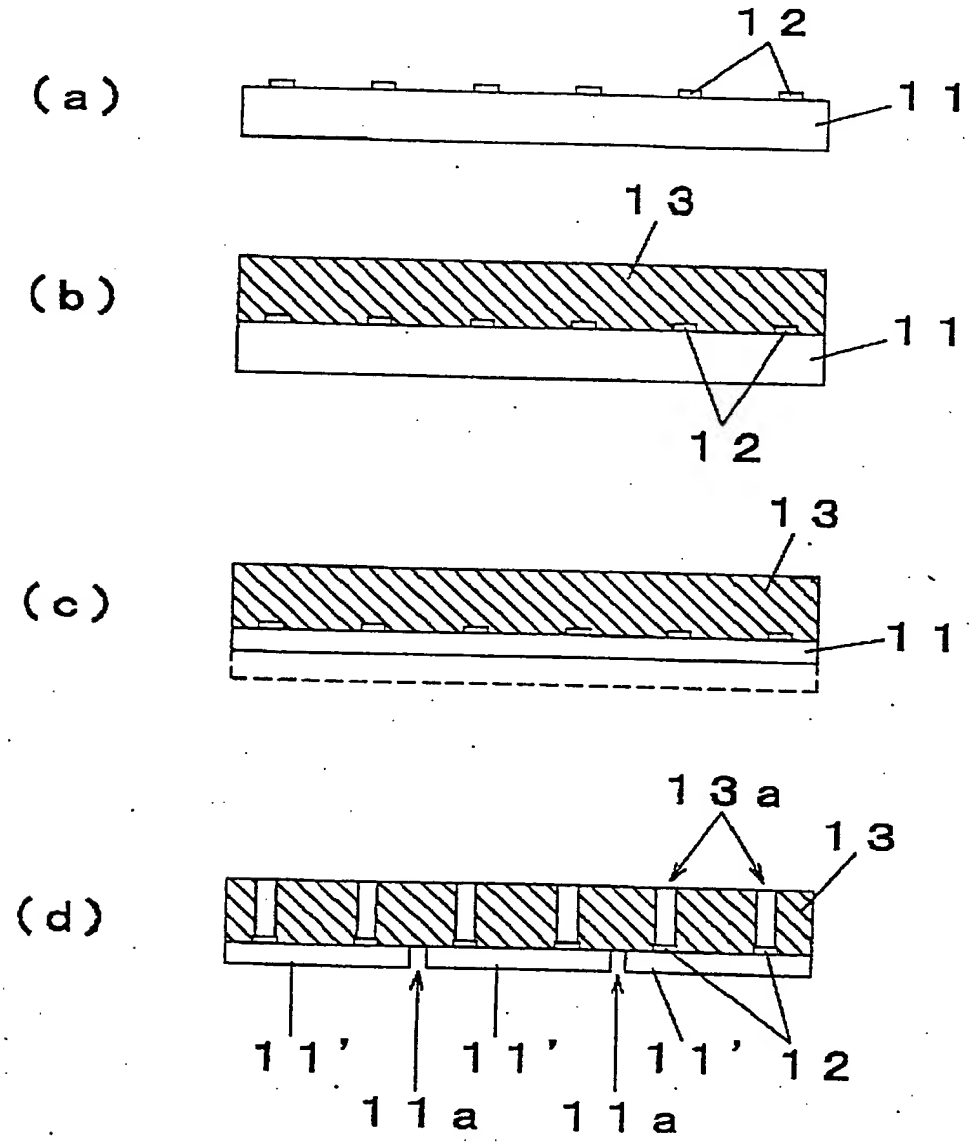
1 Semiconductor wafer
2 Electrode
3 Resin layer
3a Through-hole

[Fig. 2]



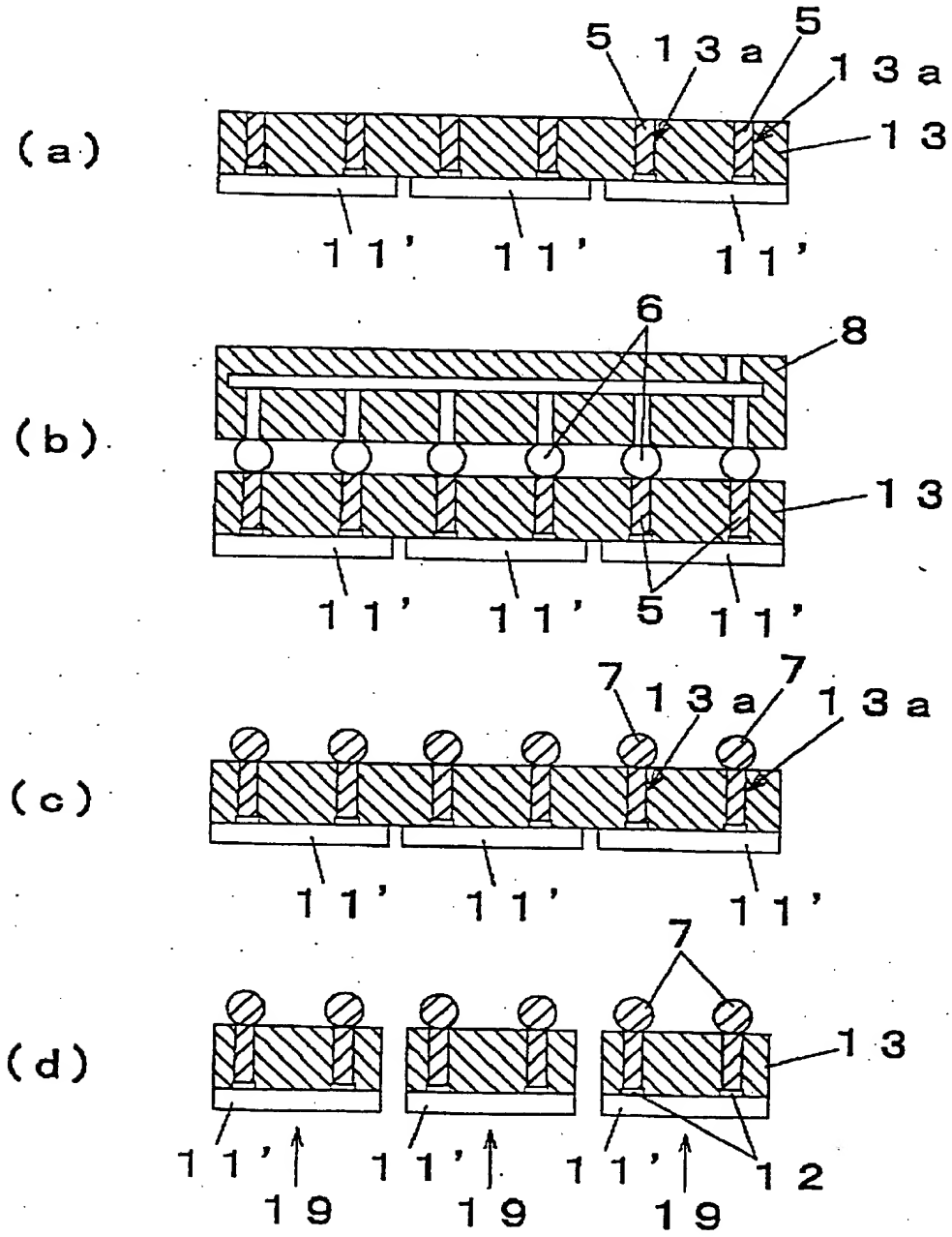
1'	Semiconductor element	7	Metallic bump
5	Cream solder	9	Semiconductor device
6	Solder ball		

[Fig. 3]



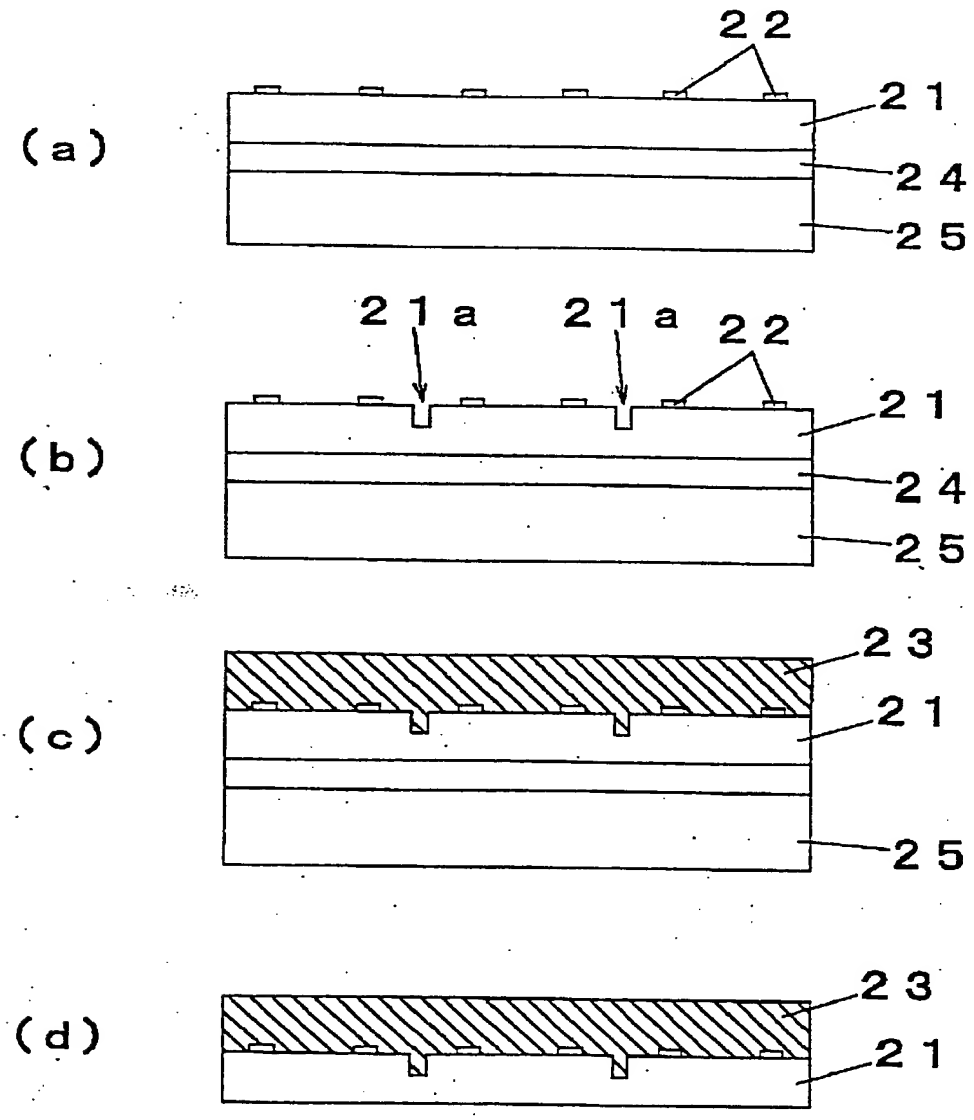
11 Semiconductor wafer
11' Semiconductor element
12 Electrode
13 Resin layer
13a Through-hole

[Fig. 4]



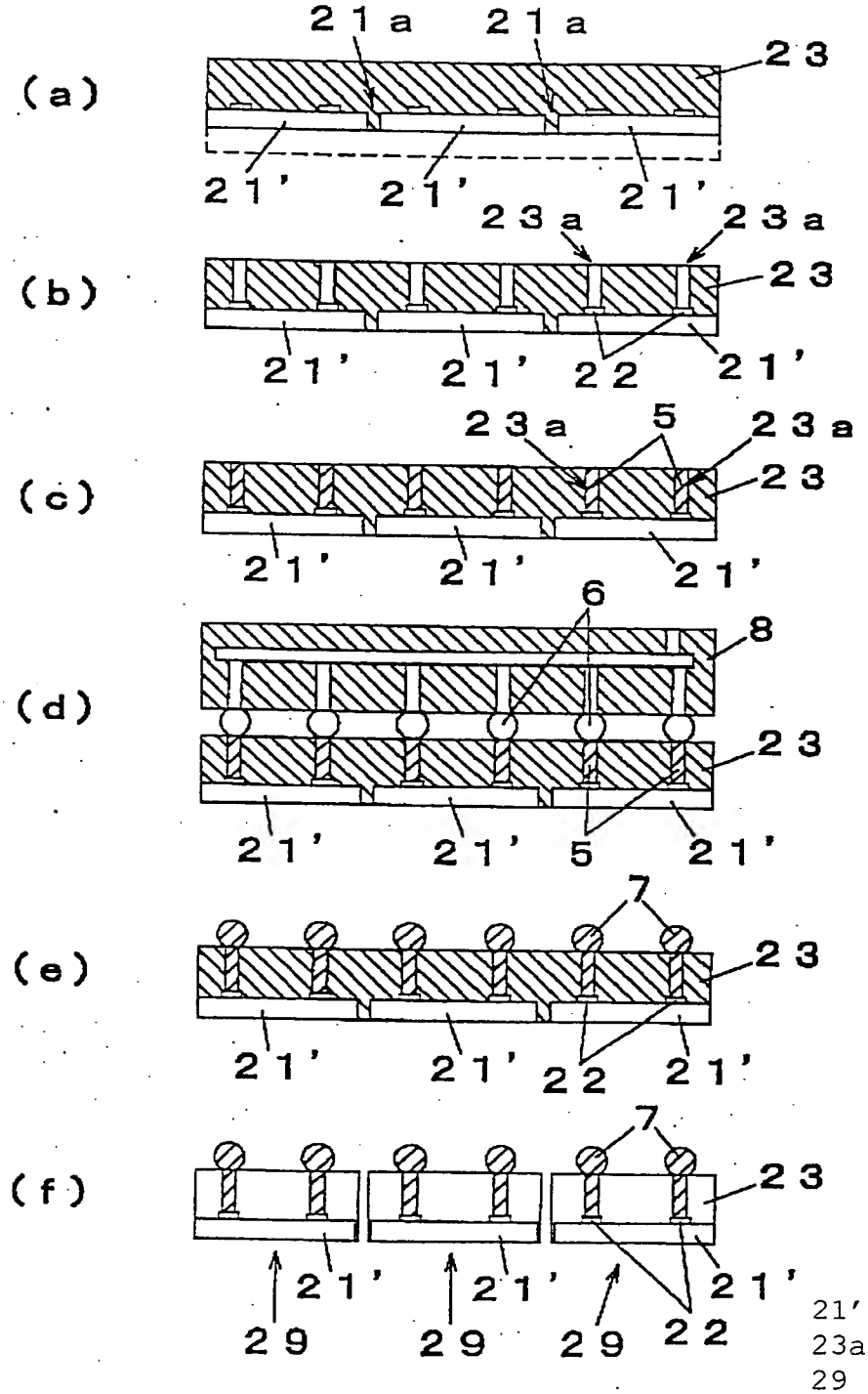
19 Semiconductor device

[Fig. 5]



21 Semiconductor wafer
22 Electrode
23 Resin layer

[Fig. 6]



21′ Semiconductor element
23a Through-hole
29 Semiconductor device